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Strength and Durability of Concrete on Replacing Fine Aggregate and Cement with Manufactured Sand and GGBS Respectively

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Abstract: ***In this study M30 grade concrete is taken as reference mix, the research is carried out in two phases. In the first phase mix of M30 grade concrete with replacement of 0%, 20%, 40%, 60%, 80% and 100% of Manufactured Sand with Natural Sand and tests were performed to evaluate workability characteristics, compressive strength, flexural strength and split tensile strength at the age of 7days, 28days, 56days and 91days.***
Durability of the concrete was tested by immersing the specimens in 1% Sulphuric acid solution for 91 days. It is observed that when Natural Sand is partially replaced with 60% Manufactured Sand maximum strength is achieved. In second phase, cement is partially replaced with GGBS by 10%, 20%, 30% and 40% and same tests were conducted. The obtained results are compared with test results of conventional concrete at all ages. The composition of 20% GGBS with 60% of Manufactured Sand gives good strength results.
Keywords: Manufactured Sand (M-sand), Natural Sand, Ground Granulated Blast Furnace Slag (GGBS), Cement, Concrete, Durability, Replacement, Compressive Strength, Split Tensile Strength, Flexural Strength and Workability.

I. INTRODUCTION

Concrete is a heterogeneous mix of cement, aggregates and water. The global consumption of Natural Sand is too high due to its extensive use in concrete.
The demand for Natural Sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. To overcome from this crisis, partial replacement of Natural Sand with Manufactured sand is economic alternative.
The concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem. Ground granulated blast furnace slag (GGBS)is one among the solid wastes generated by industry. Substantial energy and cost savings can result when industrial by-products are used as partial replacements for cement. This investigation attempts to study the feasibility of using locally available GGBS and M-sand as partial replacements for cement and sand in concrete.

II. EXPERIMENTAL INVESTIGATION

A. *Materials Used*

1) *Cement:* Ordinary Portland cement of 53 grade conforming to IS: 12269-2013, Sagar Cement brand was used.
2) *Fine Aggregate:* (River Sand) The locally available river sand passing through 4.75 mm sieve and retained on 600 µ sieve, conforming to Zone-II of IS 383-1970 has been used as fine aggregate.
3) *Manufactured Sand:*Manufactured Sand used in this work was brought from SS ROCK PRODUCTS, SURVEY NO: 303/304, KUNCHANGI VILLAGE, VISAKHAPATNAM-531032, and is conforming to Zone-II of IS 383-1970.
4) *Coarse Aggregate:*Conventional coarse aggregate was used from an established quarry satisfying the requirement of IS 383-1970. The locally available crushed granite stone is used as coarse aggregate.
5) *Ground Granulated Blast Furnace Slag (GGBS):* The GGBS used in research is obtained from Visakhapatnam Steel Plant (Visakhapatnam, Andhra Pradesh). Ground granulated blast-furnace slag is the granular material formed when molten iron blast furnace slag is rapidly chilled by immersion in water. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, and hydrates like port land cement.
6) *Super Plasticizer:* The super plasticizer used in the study was FOSROC Auramix 300.

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III. MIX DESIGN

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete having certain minimum workability, strength and durability as economically as possible. The M30 grade concrete Mix design is adopted from IS 10262:2009. As per the mix design, the quantities required for casting 3 cubes, 3 cylinders and 3 beams for each percentage replacement are computed. The table 5 below shows the mix design. Table 5- Mix Proportions.

TABLE I
MIX Proportion OF M30 Grade Concrete

Water (Litres)	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
176	400	660	1237 (742.2+494.8) (60%+40%)
0.44	1	1.65	3.09

Mix proportion adopted for M30 grade concrete is 1:1.65:3.09

IV. EXPERIMENTAL PROGRAM

The M30 mix proportioning is designed as per guidelines, according to the Indian Standard Recommended Method IS 10262- 2009. The cement, fine aggregate, coarse aggregate and the replacement are mixed in dry state and then the desired quantity of water and admixture is added and the whole concrete is mixed for five minutes. The concrete is poured in the moulds which are screwed tightly. The super plasticizer content was varied to maintain a slump of 25mm - 75mm mm for all mixtures. This research is carried out in two phases, in first phase mix of M30 grade concrete with replacement of 0%, 20%, 40%, 60%and 100% of Manufactured Sand with Natural Sand is carried out to determine the optimum percentage of replacement at which maximum strength characters are achieved.

In second phase, cement is partially replaced with GGBS by 10%, 20%, 30% and 40%. Compaction of concrete in three layers with 25 strokes of 16mm rod was carried out for each layer. Cubes of 150x150x150 mm size and cylinders of 150mm diameter 300mm height and beams of 100x100x500 mm size were tested for compression, split tensile and flexural strengths respectively. The concrete was left in the mould and allowed to set for 24 hrs before the cubes were demoulded and placed in curing tank until the day of testing. Three specimens of each set were prepared and left for curing in the curing tank for 7,28, 56 and 91 days. The specimens are removed from the curing tank and are tested for compression, split and flexural strengths and the results are compared with conventional concrete. Aggregates are graded not only to maintain cohesiveness of mix, but also to meet the grading requirements of IS:383.

After calculation of the test results, study on concrete specimens subjected to acid attack is done. In this study concrete specimens of control mix and specimens with replacement of Manufactured Sand and GGBS by Natural Sand and cement respectively are tested for Acid Resistant Test. These specimens were weighted after 28 days of curing and immersed in a tub containing diluted 1% of sulphuric acid solution for 91 days. Then the specimens are taken out and before testing each specimen is removed from the tub and brushed with the soft nylon brush and rinsed in a tap water and weighed. The percentage loss in weight and percentage reduction in compressive strength, flexural strength and split tensile strength are calculated and compared with that of control mix.

Table II
Details of mix proportions of replacements of manufactured sand and ggbs with natural sand and cement respectively

Sl. No	Type of Mix	Percentage replacement of Manufactured Sand	Percentage Replacement of GGBS
1.	A1	0	0
2.	A2	20	0
3.	A3	40	0
4.	A4	60	0
5.	A5	80	0
6.	A6	100	0
7.	B1	60	10
8.	B2	60	20
9.	B3	60	30
10.	B4	60	40

V. DISCUSSION OF TEST RESULTS

A. *Phase 1*

1) *Workability Tests:* The values of Slump cone test, Compaction factor and Vee-Bee time obtained from present investigation are presented in Table-III respectively. The Slump cone test and Compaction factor has decreased and Vee-Bee time has increased as the quantity of Manufactured Sand is increasing.

TABLE III
Workability In Terms Of Slump, Compaction Factor And Vee-Bee Time

Type of Mix	Slump(mm)	Compaction Factor	Vee-Bee Time (Seconds)
A1	59	0.96	3.25
A2	56	0.94	3.37
A3	44	0.93	4.28
A4	38	0.92	6.50
A5	35	0.90	6.75
A6	32	0.88	8.18

2) *Tests on Hardened Concrete:* Compressive strength test, split tensile strength test and flexural strength test were conducted at the end of 7, 28, 56 ,91 days on the concrete specimens. From table and figure, it can be seen that for M30 grade concrete the increase in compressive strength is of order 0%, 4.52%, 7.95%, 12.5%, 6.80%, 3.4% respectively for 0%, 20%, 40%, 60%, 80% and 100% replacement of Manufactured Sand at 28days. Increase in split tensile strength is of order 0%, 4.44%, 7.30%, 14.92%, 8.25%, 1.26% and similarly increase in flexural strength is of order 0%, 4.42%, 6.71%, 14.04%, 11.14%, 5.64% respectively for 0%, 20%, 40%, 60%, 80% and 100% replacement of Manufactured Sand at 28days**.** It is observed that the decrement of strength is more for 80% and 100% replacements. After the comparison of results, the optimum percentage replacement of Manufactured Sand with Natural Sand is found to be 60%. The test results and the corresponding graphs are as follows:

TABLE IV
Compressive, Split Tensile And Flexural Strength Results

Mix	Compressive strength (MPa)				Split tensile strength (MPa)				Flexural strength (MPa)			
	7days	28days	56days	91days	7days	28days	56days	91days	7days	28days	56days	91days
A1	25.77	39.11	41.77	42.66	2.42	3.15	3.22	3.30	5.22	6.55	6.73	6.83
A2	26.66	40.88	43.11	44	2.78	3.29	3.40	3.51	5.37	6.84	7.01	7.18
A3	28	42.22	44	44.44	3.05	3.38	3.56	3.65	5.42	6.99	7.32	7.45
A4	29.33	44	46.22	47.11	3.21	3.62	3.72	3.79	5.65	7.47	7.79	7.96
A5	28.44	41.77	44.44	44.88	2.91	3.41	3.52	3.41	5.53	7.28	7.41	7.53
A6	28	40.44	42.66	43.55	2.62	3.19	3.36	3.43	5.29	6.92	7.53	7.16

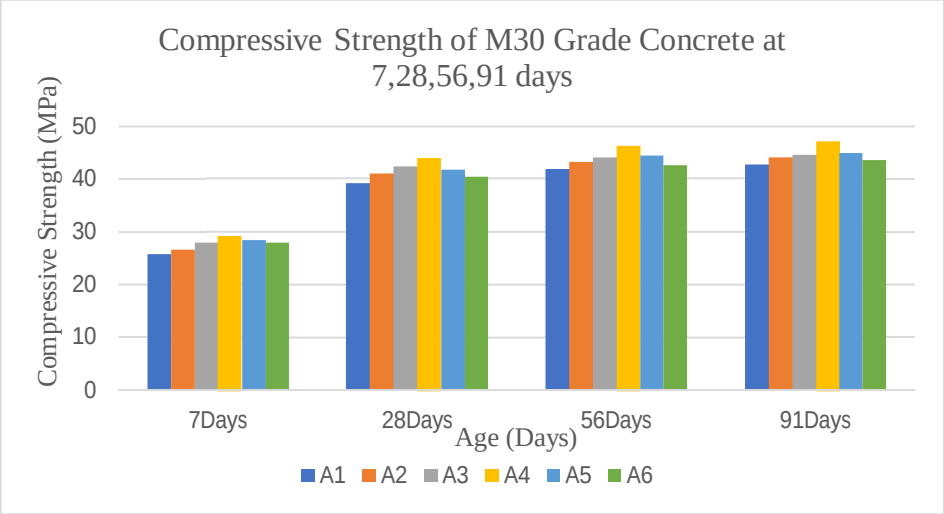


Fig. 1 Compressive strength of M30 grade concrete

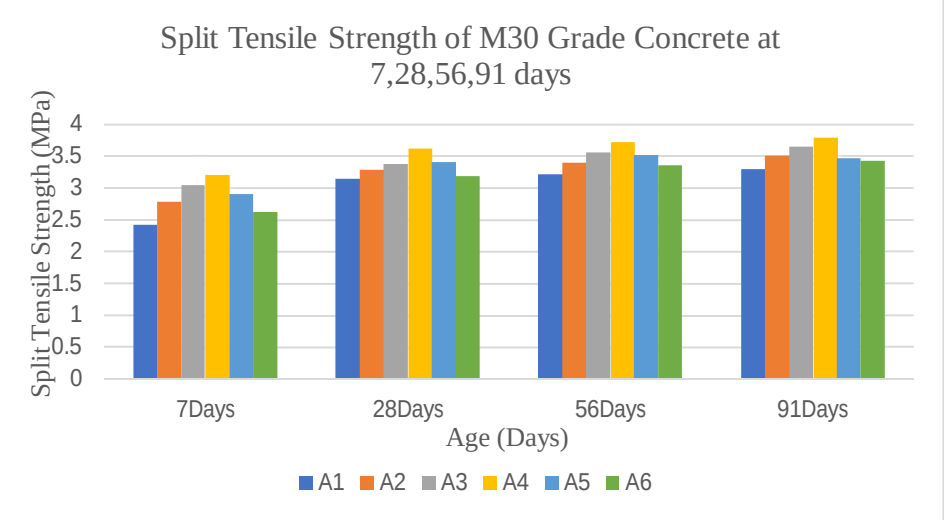


Fig. 2 Split tensile strength of M30 grade concrete

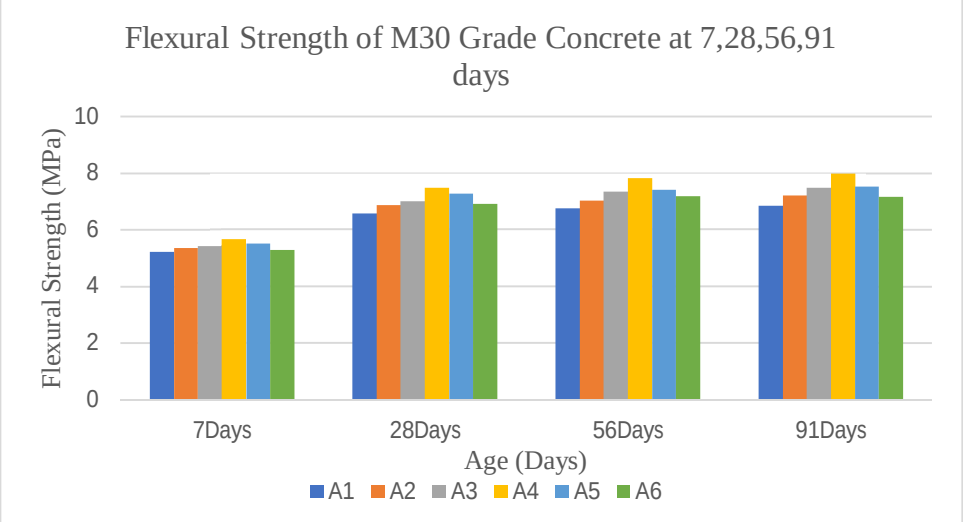


Fig. 3 Flexural strength of M30 grade concrete

3) Acid Attack: After proper water curing the specimens were exposed to 1% Dilute Sulphuric acid. The concentration of acid was measured at regular intervals and the depleted acid was replenished.

TABLE V
Effect of 1% Sulphuric Acid On Concrete Specimens

Type of Mix	Cubes		Cylinders		Prisms	
	%Weight Loss	%Loss of Compressive Strength (w.r.t 28 days strength)	%Weight Loss	%Loss of Split Tensile Strength (w.r.t 28 days strength)	%Weight Loss	%Loss of Flexural Strength (w.r.t 28 days strength)
A1	0.63	6.26%	1.15	5.39%	1.03	4.42%
A2	0.70	6.72%	0.90	7.29%	1.19	3.94%
A3	0.71	5.87%	0.85	7.10%	1.83	3.86%
A4	0.83	5.27%	0.78	6.35%	1.20	3.47%
A5	0.46	5.72%	1.98	7.62%	0.89	4.25%
A6	0.99	7.14%	1.14	8.15%	1.29	4.19%

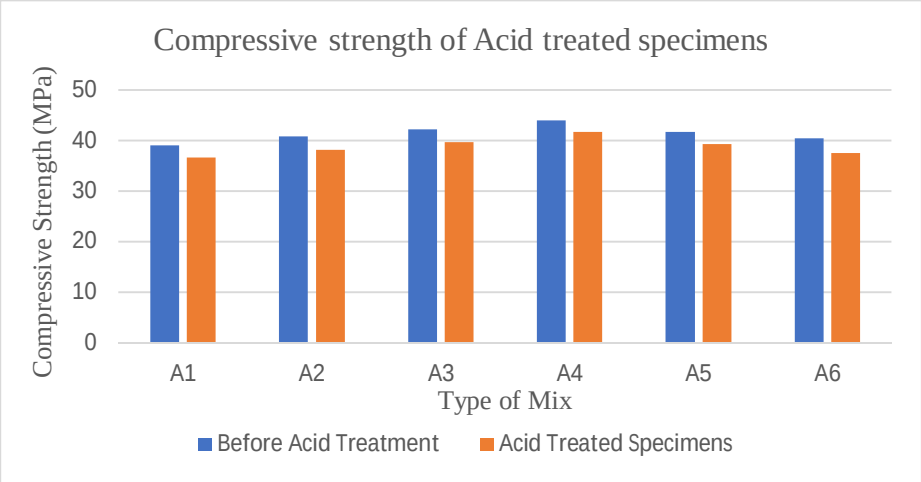


Fig. 4 Effect of 1% Sulphuric acid on concrete cubes for Compressive Strength

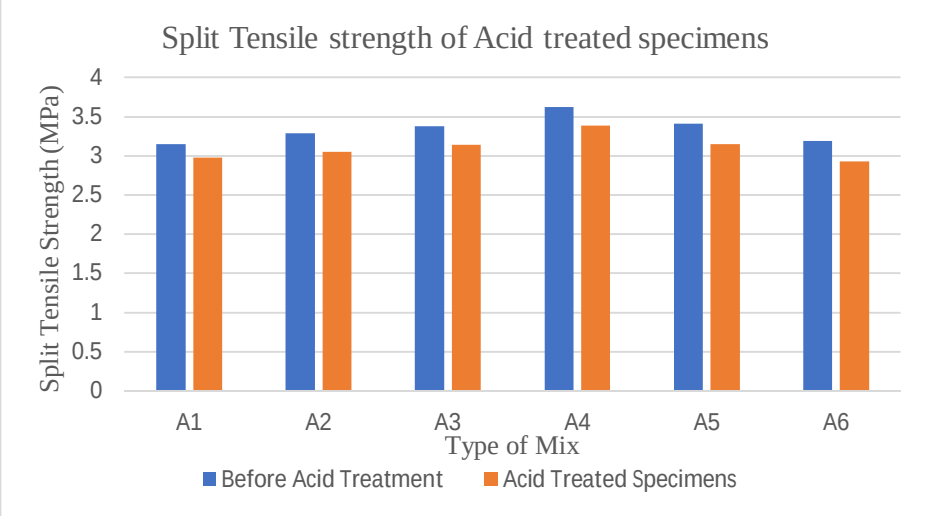


Fig. 5 Effect of 1% Sulphuric acid on concrete cylinders for Split Tensile Strength

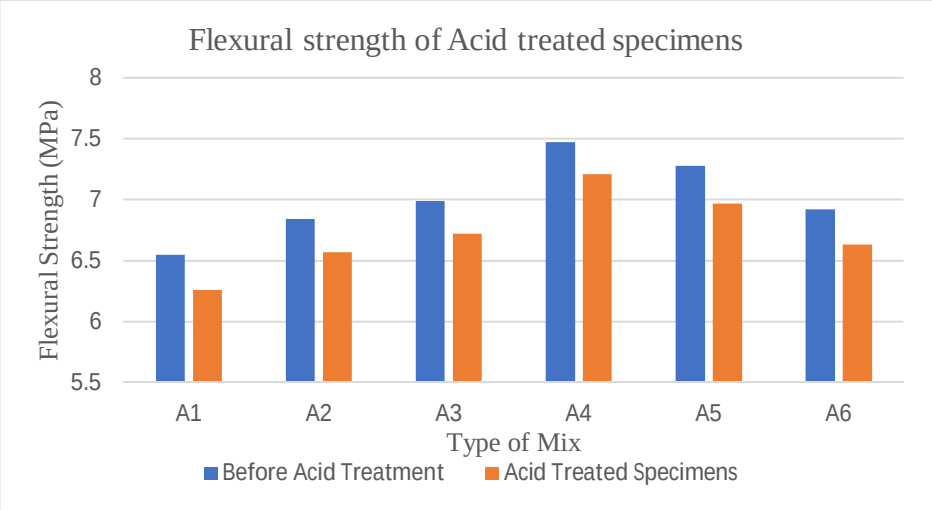


Fig. 6 Effect of 1% Sulphuric acid on concrete prisms for Flexural Strength

B. Phase 2

1) Workability Tests: The values of Slump cone test, Compaction factor and Vee-Bee time obtained from present investigation are presented in Table 6, 7 & 8 respectively. The Slump cone test and Compaction factor has decreased and Vee-Bee time has increased as the quantity of Manufactured Sand is increasing.

TABLE VI
Workability In Terms Of Slump, Compaction Factor And Vee-Bee Time

Type of Mix	Slump(mm)	Compaction Factor	Vee-Bee Time (Seconds)
B1	65	0.94	3.50
B2	50	0.93	4.28
B3	37	0.90	4.81
B4	29	0.87	8.70

2) Tests on Hardened Concrete: Compressive strength test, split tensile strength test and flexural strength test were conducted at the end of 7, 28, 56 ,91 days on the concrete specimens. From table and figure, it can be seen that for M30 grade concrete the increase in compressive strength is of order 3.4%, 7.95%, 4.52%, 2.27% respectively for 10%, 20%, 30% and 40% replacement of GGBS at 28days. Increase in split tensile strength is of order 4.44%, 11.74%, 9.20%, 6.34% and similarly increase in flexural strength is of order 02.13%, 6.56%, 3.35%, 0.45% respectively for 10%, 20%, 30% and 40% replacement of GGBS at 28days**.** It is observed that the decrement of strength is more for 30% and 40% replacements. After the comparison of results, the optimum percentage replacement of GGBS with cement is found to be 20%. The test results and the corresponding graphs are as follows:

Table VII
Compressive, Split Tensile And Flexural Strength Results

Mix	Compressive strength (MPa)				Split tensile strength (MPa)				Flexural strength (MPa)			
	7days	28days	56days	91days	7days	28days	56days	91days	7days	28days	56days	91days
B1	27.11	40.44	42.22	40	2.65	3.29	3.37	3.49	5.63	6.69	6.85	7.01
B2	28.44	42.22	44.44	42.22	2.83	3.52	3.66	3.81	6.30	6.98	7.14	7.36
B3	27.55	40.88	41.77	40.88	2.72	3.44	3.51	3.64	5.76	6.77	6.94	6.98
B4	26.22	40	40.44	39.11	2.50	3.35	3.42	3.58	5.54	6.58	6.81	6.89

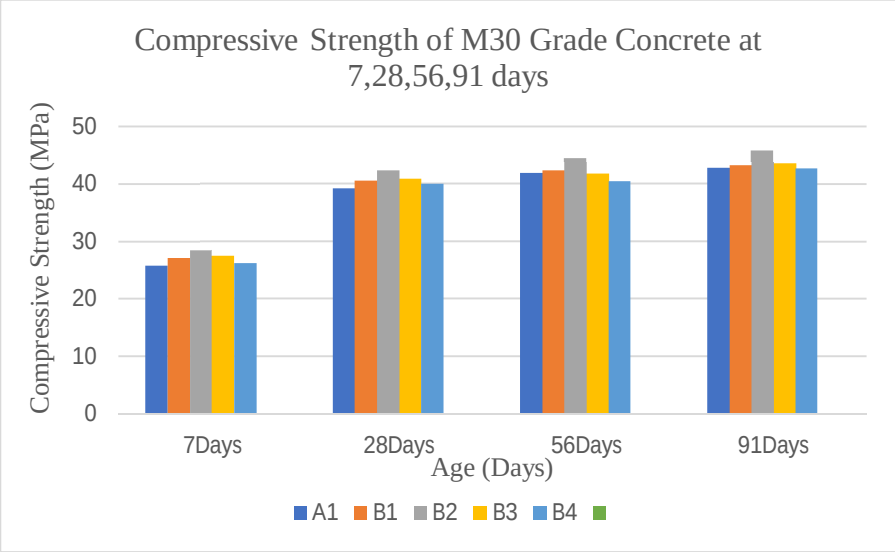


Fig. 7 Compressive strength of M30 grade concrete

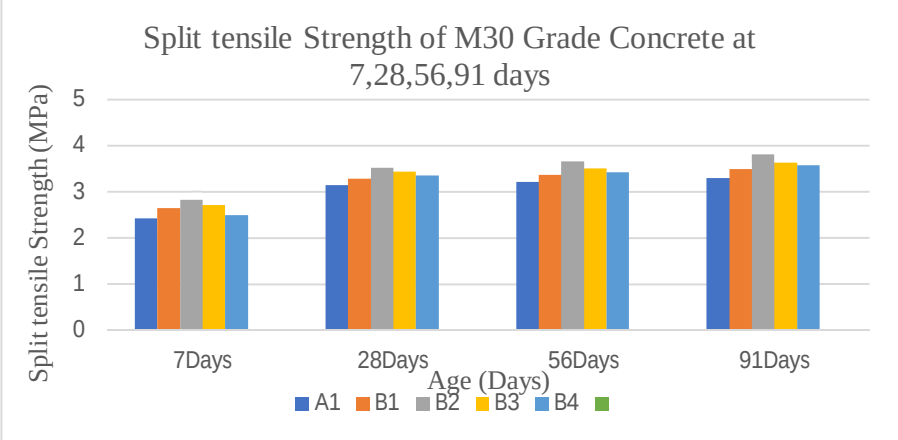


Fig. 8 Split tensile strength of M30 grade concrete

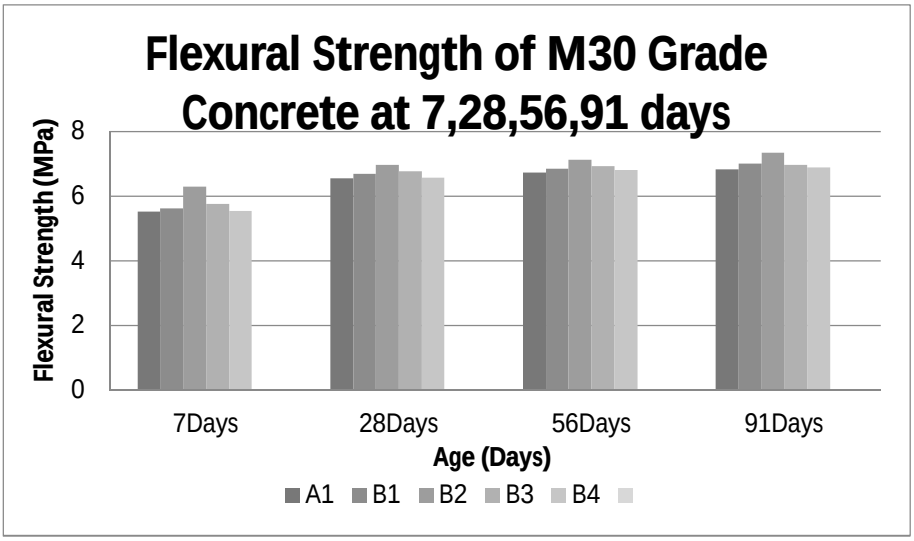


Fig. 9 Flexural strength of M30 grade concrete

3) Acid Attack

TABLE VIII
Effect OF 1% Sulphuric Acid on Concrete Specimens

Type of Mix	Cubes		Cylinders		Prisms	
	%Weight Loss	%Loss of Compressive Strength (w.r.t 28 days strength)	%Weight Loss	%Loss of Split Tensile Strength (w.r.t 28 days strength)	%Weight Loss	%Loss of Flexural Strength (w.r.t 28 days strength)
B1	1.35	6.13%	0.68	5.50%	1.41	6.87%
B2	1.67	4.92%	0.99	4.82%	0.93	5.87%
B3	1.18	6.75%	0.85	5.81%	0.73	7.09%
B4	1.37	6.25%	0.63	5.37%	0.73	6.68%

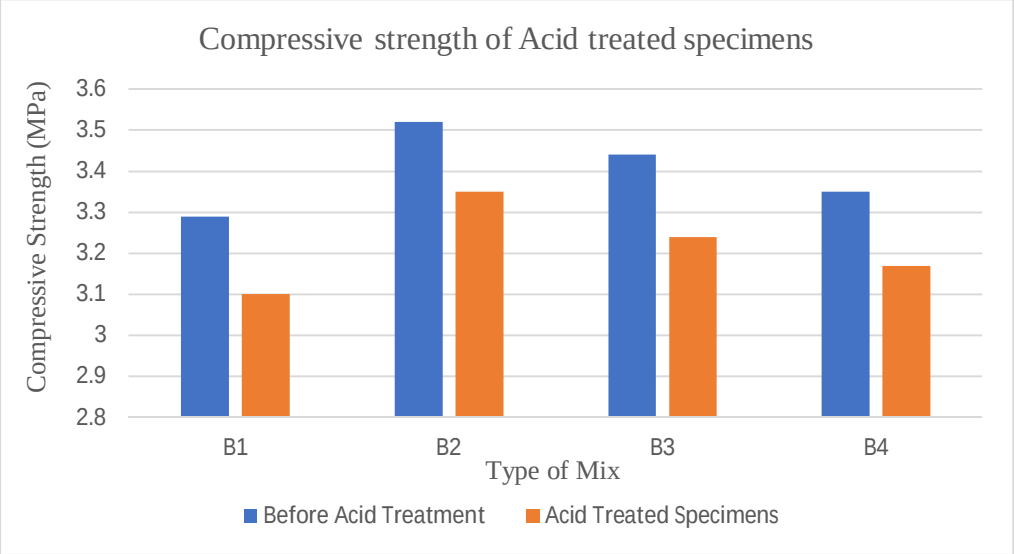


Fig. 10 Effect of 1% Sulphuric acid on concrete cubes for Compressive Strength

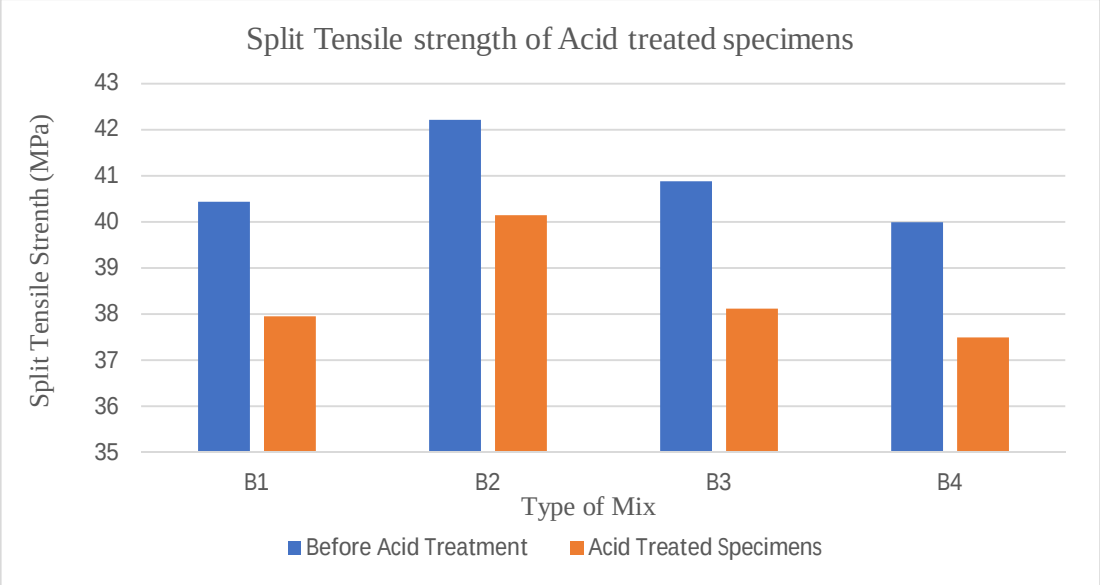


Fig. 11 Effect of 1% Sulphuric acid on concrete cylinders Split Tensile Strength

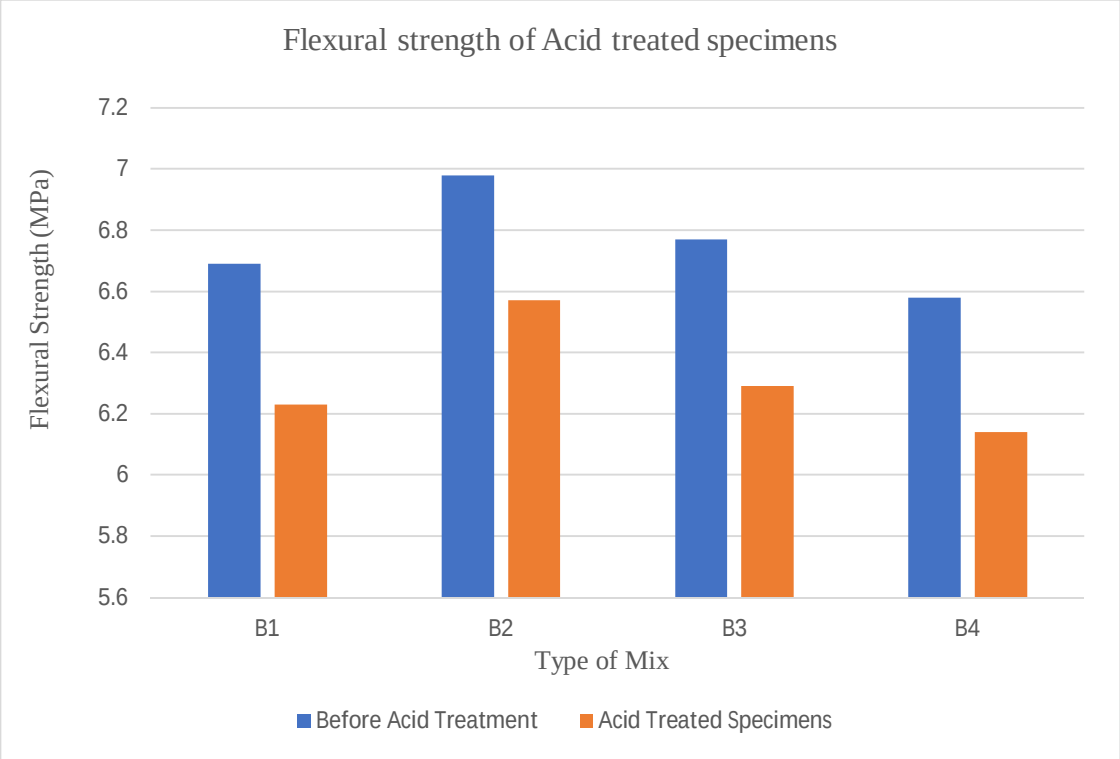


Fig. 12 Effect of 1% Sulphuric acid on concrete prisms for Flexural Strength

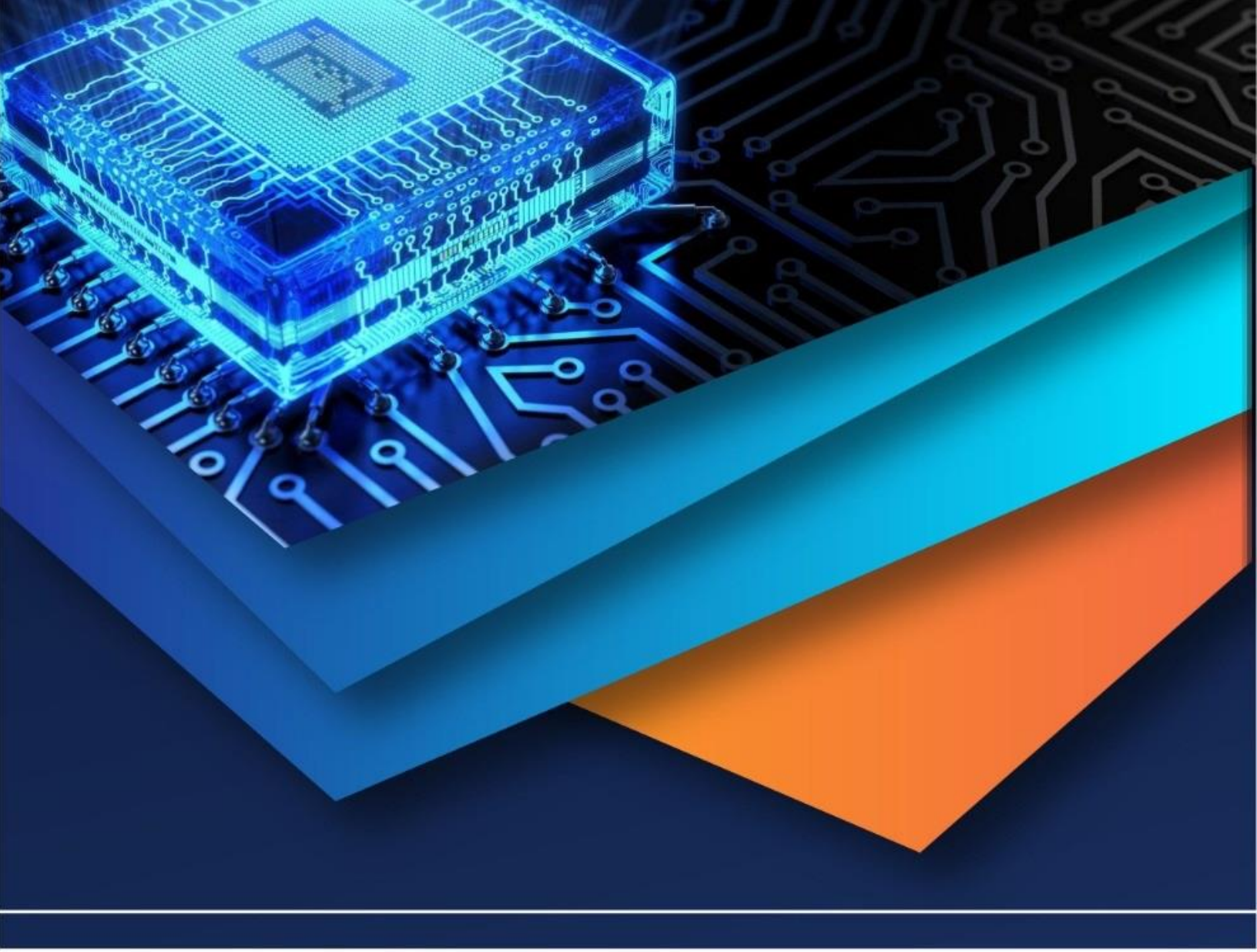
VI. CONCLUSIONS

Based on the results presented above, the following conclusions can be drawn:

1) Compressive strength increases with increase of percent of Manufactured Sand up to certain limit.
2) It is observed that 60% replacement of Natural Sand by Manufactured Sand is giving better compressive strength for M30 grade concrete compared to other proportions of mixes. This percentage replacement is named as optimum percentage.
3) The maximum 28 days split tensile strength was obtained with 60% Manufactured Sand replacement with Natural Sand when compared to all other mixes.
4) The maximum 28 days flexural strength was obtained with 60% Manufactured Sand replacement with Natural Sand when compared to all other mixes.
5) It is observed that 60% replacement of Natural Sand by Manufactured Sand is giving better resistance to acid attack for M30 grade concrete compared to other proportions of mixes.
6) As percentage of Manufactured Sand increases slump value and compaction factor value decreases, whereas vee-bee time increases.
7) By adopting same optimum percentage of Manufactured Sand and replacing cement by GGBS, it is found that slump value and compaction factor value decreases, whereas vee-bee time increases with increase in GGBS percentage in concrete.
8) It is observed that 20% replacement of cement by GGBS is giving better compressive strength for M30 grade concrete compared to other proportions of mixes.
9) It is observed that 20% replacement of cement by GGBS is giving better split tensile strength for M30 grade concrete compared to other proportions of mixes.
10) It is observed that 20% replacement of cement by GGBS is giving better flexural strength for M30 grade concrete compared to other proportions of mixes.
11) It is observed that 20% replacement of cement by GGBS is giving better resistance to acid attack for M30 grade concrete compared to other proportions of mixes.
12) The Manufactured Sand and GGBS can be used as a best alternative material for partial replacement of Natural Sand and cement respectively. The combination of 60% Manufactured Sand and 20% GGBS replacement gives better results when compared to other replacements.

REFERENCES

[1] Christina Mary V. and Kishore CH. Experimental Investigation on Strength and Durability characteristics of High Performance Concrete using GGBS And M-sand. 2015; ISSN: 1819-6608.
[2] Sonali K. Gadpalliwar, R. S. Deotale, Abhijeet R. Narde. To Study the Partial Replacement of Cement by GGBS & RHA and Natural Sand by Quarry Sand in Concrete. 2014; ISSN: 2320-334X.
[3] R. Subashini, T. Sonia, Dr. M. Shahul Hameed. Study on behavior of M-Sand Concrete using GGBS as Filler. 2016; ISSN: 2349-784X.
[4] S.Krishna Rao, P.Sravana, T.Chandrasekhara Rao. Effect of M-Sand and GGBS on Strength and Compaction Characteristics of Roller Compacted Concrete Pavement (RCCP). 2015: ISSN: 2319-1163.
[5] IS: 12269-2013. Specification for 53 grade ordinary Portland cement. Bureau of Indian Standards, New Delhi.
[6] IS: 383-1970. Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian standards, New Delhi.
[7] IS: 2386-1963 Part I to VIII. Indian standard Methods of test for aggregate for concrete. Bureau of Indian standards, New Delhi.
[8] IS: 1199-1959. Indian standard methods of sampling and analysis of concrete. Bureau of Indian standards, New Delhi.
[9] IS: 516-1959. Indian standard methods of test for strength of concrete. Bureau of Indian standards, New Delhi.
[10] IS: 10262-2009 and SP 23: 1982. Recommended guidelines for concrete mix. Bureau of Indian standards, New Delhi.
[11] Plain and Reinforced Concrete Code of Practice (Fourth Revision), IS 456:2000, Bureau of Indian Standards, New Delhi.
[12] M.S. Shetty “Concrete technology” S.Chand and Co.Ltd, India (2009).



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